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ARTICLE

Blind Spots on Achilles' Heel: The Limitations of Vulnerability and Resilience Mapping in Research

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Abstract The mapping of vulnerability and resilience has become an important tool for vulnerability and resilience research. By definition, maps are selective representations. However, the predominant methods of mapping also have constraints. When addressing vulnerability and resilience, these limitations, barriers, and blind spots have to be taken into account. Some aspects cannot be easily mapped, such as specific forms of knowledge and interpretation, the processuality of vulnerability and resilience, the dynamics of social processes, the context of origin, the establishment of contingent interpretations, and so on. These limitations are not only theoretically important, but also are practically significant, since maps themselves become *dispositifs*. They are regarded as representations of reality, shape particular interpretations of vulnerability and resilience, and are used as a basis for decision-making. If the unmapped preconditions of mapping remain unconsidered, this can lead to problematic side effects.

Keywords Cartographic bias · Foucault · Mapping constraints · Vulnerability mapping

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1 Introduction

The mapping of vulnerability and resilience has become an important tool and one of the predominant quantitative forms of expression for vulnerability and resilience research for practical experts, politicians, and other groups, but also the general public. Maps provide important insights into spatial dimensions and the relations of vulnerability and resilience; they can enhance risk communication and support decision-making in all phases of disaster management (Edwards et al. 2007). But as the practical experience within our collaborative research effort has demonstrated, the predominant methods of mapping also have constraints, barriers, and blind spots. These limitations are not only theoretically or epistemologically important, but also have practical and political consequences. This article discusses these limitations and consequences.

Maps are, by definition, selective representations (Black 1997; Raffestin 2003), since they need to be limited to certain aspects to obtain a heuristic value. Thus, Monmonier (1996, p. 1) points out that it is "not only […] easy to lie with maps, it's essential. […] There's no escape from the cartographic paradox: to present a useful and truthful picture, an accurate map must tell white lies." Commonly these white lies become hidden, because maps tend to naturalize themselves through the reproduction of a sign system that is presented as given. As Pickles writes, "map knowledge is never naïvely given. It has to be learned and the mapping codes and skills have to be culturally reproduced" (Pickles 2004, p. 61). The predominant mapping procedures build on specific codes and standards, on epistemologically and discursively framed background knowledge, and on associated texts and cultural contexts of interpretation and action (Wood and Fels 2008), both in

their production and in their reading. These foundations are embedded in a certain Western scientific culture (Harley 2001d) in which non-Western or other variant cartographies are often not acknowledged (Pickles 2004). Furthermore, different forms of knowledge, interpretations, and meanings often simply cannot be mapped at all within the script-focused Western sign system. Referring to the work of Dauenhauer (1980), Harley (2001c, p. 84) termed this "intentional and unintentional suppression of knowledge in maps" *cartographic silence.* With the digitalization of mapping, we increasingly have to take into account the relevance of the influence of the instruments being used in the mapping process, as Curry (1998) has pointed out for geo-information systems (GIS). Map-making always involves making choices about what will be represented and what will not. However, the ontologies upon which geo-information systems are based often remain invisible, and are often not questioned by the users.

This article reveals such limitations and blind spots, as well as the agency of vulnerability and resilience mappings. Beginning with some fundamental remarks on the concepts of vulnerability and resilience, the tension between a rather phenomenological conception and the restraints of mapping vulnerability and resilience is introduced and outlined. This is followed by the central argument, that social processes are spatialized and objectified by mappings. Even if this basic difficulty is acknowledged, the validity of mappings may remain an issue due to questionable data sources, statistical and other methodological problems, and their visual representation. Spatialization, objectivation, and constrained validity are not just of theoretical importance; rather, they become even more crucial to shaping the reality of mappings as determining factors. We do not argue against mapping as such, but rather call for critical reflection on its restraints, careful use and, where possible, complementary consideration of other data sources, as well as the combination of different quantitative and qualitative methods.

This article is based on collaborative research by the International Center for Ethics in the Sciences and Humanities (IZEW) of the University of Tübingen and the Disaster Research Unit (DRU) of the Freie Universität Berlin.[1] While the IZEW focused on the ethical implications of using GIS in security and safety research in general, the DRU conducted a vulnerability assessment study at the urban district level, and also carried out the development and testing of an alternative participative study design to assess vulnerability in specific social spaces. The research carried out by the DRU involved the use of GIS and mapping tools. During the course of this specific research, the limitations of using such systems became increasingly obvious. When discussing the particular issues such as the representation and its implications it became clear that some of the limitations and challenges experienced by the authors are fundamental. Therefore, this article brings together insights from theory and practice to provide a deeper understanding of the limitations of vulnerability and resilience mapping.

[1] This research is part of the collaborative research project BASID (Security Barometer for Germany), which is a transdisciplinary collaborative project of six partners from academia and practice. It was funded by the German Federal Ministry of Education (BMBF).

2 The Concepts of Vulnerability and Resilience

The concept of vulnerability emerged within different fields (in the context of natural hazards and risk research, for example, in research on famine, disaster mitigation, the insurance business, and development) to help in understanding the condition or the predisposition of a system to suffer harm due to a hazard (Adger 2006). The definition of what should be understood by "vulnerability" is hotly contested within scientific and economic groups (such as the insurance industry), as well as in everyday life (Yamin et al. 2005). A rather simplistic view, which defines vulnerability as the probability that a social, ecological, or physical reference unit will suffer harm in the case of a certain event, is confronted with numerous other conceptions, including further interdependent influencing factors, and means of protection referring to different time scales, spatial references, and so forth (Voss 2008).

The mapping of vulnerability reduces differences and interdependencies on the reflexive-conceptual level. Especially mappings of social vulnerability on the global scale might render whole continents as vulnerable to hunger or poverty, but not scrutinize the heterogeneous historical, political, and cultural conditions that led to these threats. The global approach to the mapping of vulnerability is generally dominated by single natural hazards like tsunamis or earthquakes, focusing for example on the geographical reach of waves, or the magnitudes and the frequency of their occurrence (see, for instance, the *Vulnerability Atlas of India* (BMTPC 1999), or the *World Risk Report* (Alliance Development Works 2013)). But the magnitude of extreme natural processes alone does not convey any information about their social relevance. A red-colored coastal zone displaying risk of a tsunami (Sinaga et al. 2011) does not necessarily indicate social vulnerability, if people living within this area prepare themselves adequately through building standards, warning systems, and an internalized disaster culture. If such a culture exists, there might be some specific ecological but no social vulnerability, even if tsunamis are probable. In the practical use of the term vulnerability, these different references—

ecological, social, and physical—are often mixed up, and sometimes it is simply forgotten that exposure is only one precondition of vulnerability, not vulnerability itself. A *Handbook for Vulnerability Mapping*, for instance, gives the following advice: "Vulnerable sites are those where people live, work and visit" (Edwards et al. 2007, p. 6).

Furthermore, the background assumption that the effects of deviation triggered by a natural dynamic have to be solely negative, as long as they potentially cause biophysical harm or human casualties, is a social construction that serves as a basis for every form of mapping. What is seen as negative and damaged depends on cultural norms and patterns of interpretation (Douglas and Wildavsky 1982). Forms of loss are framed by different cosmologies, leading to very different ways of dealing with loss, ranging from repression strategies to full acceptance or fatalism. There are many scientific approaches that try hard to include these social and cultural aspects and their positive and negative effects in mapping, and some are more successful than others. Nevertheless, we maintain that cartography has general limitations in representing these relativistic, highly complex cultural conditions. The more global the perspective, the higher the likelihood that relevant cultural or social determinants, or other factors enhancing or reducing the possible effects of an extreme natural event (for example, coping mechanisms that help people to live with chronic problems, or rituals that conserve collective memories of past events) tend to be neglected (see again the *World Risk Report* (Alliance Development Works 2013) as an example).

Most of what has been said before with respect to vulnerability is true for resilience as well. The concept has its background in very different disciplines and its meaning is—perhaps even more—contested. The root word *resilire* was first mentioned in ancient Rome by Lucius Annaeus Seneca (Alexander 2013), and since the 1950s the concept has been used in psychological (Werner 1971) and sociological studies (Antonovsky 1979). The concept underwent its most prominent reinvention within the field of social ecology through C. S. Holling's studies in the 1970s (Holling 1973), and spread across many disciplines over the next two decades, ascending to the core of different discourses, for example, disaster risk reduction (DRR), disaster education and prevention, risk communication, and sustainability, among others. Instead of questioning which hazards or other factors enhance vulnerability, the resilience approach emphasizes the factors that allow people, groups of people, animal populations, or whole ecosystems to cope with extreme dynamics in their biophysical environment, including, in the case of humans, social setting. The resilience approach asks why some humans become traumatized, while others can continue to live their "normal" lives without morbid transformation, while being exposed to the same pressure or stress. The resilience approach further asks how people adapt to their environments, building capacities relevant to the specific challenges to which they are exposed.

Culturally shaped worldviews, norms, and values play a crucial role, developed through a constant grappling with the biophysical and social environment. Seen through the resilience lens, understanding of loss, risks, and hazards becomes correspondingly relative. Without going so far as to argue for a radical cultural relativism, it should be noted that the meaning attached to vulnerability and loss does not primarily evolve from recourse to single key figures, but only emerges when such concepts are linked back to individual and cultural systems of meaning or cosmologies. These systems of meaning usually consist of irreducible dimensions that cannot be quantified. This means that certain assessment criteria that may be difficult to quantify have to be given consideration in vulnerability and resilience. Every quantifying assessment is thereby limited in scope, and pure analytical figures prove insufficient when it comes to cultural significance. This is all the more true when dealing with different cultures with different value systems, but also stands for studies within cultures. Certain forms of susceptibility and loss are historically and culturally accepted, and are considered "normal" in contrast to others (Macamo 2003).

Therefore, different strategies to protect life can be seen as "normal," and against the background of varying cosmologies they are justified differently. Strategies to reduce vulnerability and enhance resilience are only rational in part, yet remain so implicitly. To a large extent, people let themselves "float" without reflection; they are led by others, or are driven by economic and political forces. These rather "practical" strategies (Bourdieu 2000) are developed in a coevolutionary process of humans and environment. Such highly complex, multilevel, dynamic, and nonlinear strategies, developed in different environments, can never be fully captured by objectifying methods, which necessarily abstract from those mutually supportive and stabilizing relational, nonlinear processes. Emanating from a positivistic position, vulnerability and resilience research is slowly opening up to this complexity. The mapping of vulnerability and resilience is an important tool. But it also runs the risk of slowing down this creeping paradigm shift (McEntire 2004).

3 Mapping Spatializes and Objectifies Social Processes

The predominant methods of mapping are only able to depict processes—especially social processes—to a limited extent. Social phenomena often cannot be mapped in the same way as physical objects or natural events, that is, with

a certain fixed location in space. Social phenomena belong to a distinct ontology, and they evade geographical fixation as they are not tied to objective representation. Time remains a crucial dimension in maps (Wood 2010). The majority of maps still designate only a physical place at a certain point in time, where all social processes that constitute reality stand still (Schlögel 2003), even though there have been major steps forward in mapping dynamics. Therefore, processes are only seen as a snapshot without development, or are filtered out. Many processes do not even enter maps in the first place, due to distant spatial or temporal drivers, societal meaning and relevance, and transformation over time (although this is hidden in a map; Wood 2010). For example, vulnerability as "a product of the past" (Hilhorst and Bankoff 2004, p. 3) or as a result of distant societal and historical processes (Hewitt 1997; Blaikie et al. 1994) often incorporates subliminal causes over long periods of time, such as colonialism or globalization, that are nearly impossible to show in a map. To understand fully the production of vulnerability and resilience, the underlying social causes need representation in their processual character, implying that different spatial and temporal scales are incorporated (Black 1997). Vulnerability and resilience research runs the risk of falling prey to the "fallacy of misplaced concreteness" (Whitehead 1925, 1997), where abstract concepts are treated as alleged single spatial causes at a contingent element of time in the mapping. The abstract concepts of vulnerability and resilience cannot be limited to isolated factors that can be located and displayed easily. The fallacy of misplaced concreteness involves the objectification or the reification (Berger and Luckmann 1966) of vulnerability and resilience, that is, they are merely apprehended as natural circumstances and not as a product of various social processes (Hilhorst and Bankoff 2004).

However, in terms of media theory, actor-network theory, and affiliated approaches of critical theory or cultural studies, a so-called objectification through mapping can be described as a "normal" process (Pickering 2001). To objectify social processes in a map means producing one cultural code rather than other, competing cultural codes. As a result of this approach, not only is the objectification itself critical, but also the discourses or narratives that lead to it. With regard to the mapping of vulnerability, this suggests not only that the use of geographic information systems and the corresponding special languages is problematic, but also potentially that the tacit justification links for vulnerability and insecurity can gain authority and power by using a seemingly neutral map (Glasze et al. 2005; Harendt and Sprunk 2011). In this perspective, maps have to be regarded as objectifications—which media in general always are. Similar to other media like television, newspapers, or books, maps show a certain perspective on the different possible views of reality in relation to a specific set of instruments. In a media-critical approach, questions are essential about how a sign system is used and in which way other perspectives are excluded by a special form of representation. For a more comprehensive understanding of geographic information systems, a critical analysis of data sources is a first condition.

4 Problems of Data Sources and Data Analysis

Vulnerability (and resilience) maps display the "location of sites where people, the natural environment or property are [not] at risk due to a potentially catastrophic event that could result in death, injury, pollution or other destruction" (Edwards et al. 2007, p. 3). Such maps are the complex product of data indicating vulnerability or resilience projected onto a map. But where do the data come from, and how are they processed? One common procedure is that researchers with a general understanding of the concepts of vulnerability and resilience look at the basis of statistical data to see which indicators they can identify. Different groups of social, economic, and demographic indicators may be combined with physical and land use data to predict and categorize levels of community vulnerability or resilience. In order to combine multiple indicators and maximize area coverage, the easy availability of large databases and geographic information systems provide an apparent viable solution. This poses the danger "that community vulnerability is defined and measured by and through the available large databases, such as the census, because they are there, rather than because these databases encapsulate vulnerability" (King 2001, p. 147). This is even more problematic in the case of resilience, since the concept and indicators of resilience are even more contested (Carpenter et al. 2001; Klein et al. 2003; Brand and Jax 2007).

Practical questions arise from census data and other surveys collected for purposes other than vulnerability and resilience mapping. These concern content and phenomenology, as well as spatial and temporal adequacy. Regarding general problems with census data, King (2001) extensively discusses the limitations of using socioeconomic indicators to predict a community's vulnerability to natural hazards. Standardized sets of census data exclude many variables relevant to vulnerability and resilience. Therefore, some factors that influence vulnerability and resilience to a great extent, such as risk perception, social networks, preparedness measures, are more prone to cartographic silence than others. Studies show that people's awareness and preparedness does not always coincide with defined vulnerability characteristics (for example, elderly people were highly aware and prepared, while young migrants were not). An important aspect is the

incongruence of spatial and social entities, since the boundaries of communities in terms of social ties are often at odds with administrative borders. Data decay is another prominent problem: with the passage of time, census data ceases to be valid and up-to-date due to mobility, migration, and social change. Nonetheless, the knowledge of the changing patterns of vulnerable groups' residences (single-parent families, elderly, and so on) is crucial to emergency planners (King 2001; Hufschmidt 2009; Fekete 2012).

When analyzing and processing spatial data, several statistical problems may arise that are amplified by their visual representation in vulnerability maps. One of the most discussed issues is the definition of data collection districts or analytical spatial units. As for census data, the boundaries of the collection districts have to be constant, but the population may vary heavily; thus it is difficult to achieve homogeneity regarding population numbers or equality (King 2001; Fekete 2012), though some (theoretical) approaches have been proposed to overcome this difficulty (Openshaw 1984; Madelin et al. 2009). The arbitrariness of the analytical units' definition is mostly pragmatically motivated, but may sometimes be politically motivated also. However, it almost inevitably leads to a statistical bias called "modifiable areal unit problem" (MAUP). The issue was described in detail by Openshaw (1984, p. 4): "Whereas census data are collected for essentially non-modifiable entities (people, households) they are reported for arbitrary and modifiable areal units (enumeration districts, wards, local authorities)." Recognition of the MAUP has resulted in a number of proposed solutions, such as interpolation and smoothing, the visualization of size effects in cartograms, gridding-methods, and interactive cartography (Madelin et al. 2009).

Transparency is crucial in how analytical spatial units are defined and how statistical results are derived from the collected data. This holds true for processes of data aggregation and standardization as well. Data has to be aggregated for privacy protection and easier data handling, but detail and precision are lost in this process (King 2001). Standardizing data is crucial for comparison. It allows the use of multivariate methods, but the variety within aggregations is no longer visible. As Klinenberg (2003) showed in his study of the 1995 Chicago heat wave, vulnerability and resilience are the result of an interplay of certain indicators: the most affected population in the case of the heat wave was old *and* poor *and* isolated *and* African American *and* living in areas with high violent crime rates. Aggregated and standardized data may not reveal this interaction of indicators; this can mislead decision-makers, but such data can also be misused by them for their own interests. Connected to the problems of data aggregation is the question of "ecological fallacy." Ecological fallacies can occur when an inference is made about an individual from higher levels of aggregation (Meentemeyer 1989). This may lead to the implicit assumption that people in one region are "equally" vulnerable, as illustrated by the case of food insecurity in Ethiopia (Stephen 2004): early-warning decision-makers conceptualize the spatial dimension of food security as aggregated because this serves their own and international agendas. As a consequence, localized problems do not command the solutions or resources that they should.

Classification also turns out to be problematic. A typical means of showing data by the classification of categories are choropleth maps, where areas are shaded in relation to the classified statistical measure, for example, population density. Choropleth maps are often used in inappropriate applications; class breaks are artificial separations that can be manipulated to yield choropleth maps supporting (politically) divergent interpretations. Existing alternatives to classic choropleth maps include cartography of ratios, proportions, and visualization of reference values (Madelin et al. 2009).

Apart from statistical problems, the visual (re)presentation of the statistical data implies generic problems of its own. Cartographic subtleties such as projection, generalization, color schemes, and so on may lead to misinterpretations of maps. Knowledge about the effects of colors and shades cannot be assumed to be globally consistent. Therefore it is necessary to explain the meaning of symbols, signs, and colors in maps, recognizing cultural differences, and to be careful and cautious when reading and interpreting maps from the perspective of a different cultural context.

5 Maps as *Dispositif*

Maps do not represent reality; instead they have a performative character: "By constant processes of referencing, citing, layering, the map accumulates social assent and, historically, has established itself as an 'authoritative' reference object" (Pickles 2008, x). In the manufacturing of maps, certain patterns of data interpretation are determined. In turn, the form of determination is an expression and empowerment of a certain claim of validity. Maps are similar to other semantic systems in that they are a medium for intersubjective processes of reaching understanding of dominant ascriptions of significance (Harley 2001b; Wood 2010). If a context of justification within a certain semiotic system is established by mapping, it becomes "an authority that may be hard to dislodge" (Harley 2001a, p. 168), since alternative facts, linkages, and interpretations may not be displayed within the semiotic system.

With the given agency of the mapping, other concurrent interpretations are excluded. Therefore, maps that originate

from the alleged attempt at being descriptive and reducing reality's complexity become prescriptive and establish singular meanings and interpretations that become themselves part of reality and the background for interpretation of the world (Wood 1992; Wood and Fels 2008). In the words of Harley (2001b, p. 79), cartography often "remains a teleological discourse, reifying power, reinforcing the status quo, and freezing social interactions within charted lines."

In this context, the French philosopher and sociologist Michel Foucault coined the concept of *dispositif*, or "apparatus." *Dispositifs* are (mostly invisible) implementations of different manners of power in discourses, institutions, architecture, administration, science, and so on (Foucault 2008): "Endeavouring […] to decipher discourse through the use of spatial, strategic metaphors enables one to grasp precisely the points at which discourses are transformed in, through and on the basis of relations of power" (Foucault 1980, p. 69). A *dispositif* supports certain types of knowledge (Foucault 2008), and in this sense maps produce and stabilize the ascription of knowledge and power. Like statistics (Porter 1995), maps may legitimize decisions by giving decision-makers something concrete with which to justify themselves. This seems a reasonable parallel, given the similarities between statistics and maps described in the literature (Raffestin 2003).[2]

Moreover, maps are commensurate with the demands of internet communication and traditional broadcasting media: both ask for visualizations and a simple "language," and they both promote a visual trend that is also evidenced, for example, in the growing number of pictorial representations in online communication (for example, icons). In media theory and practice, the reduction of reality by numbers and statistics is an important and common method to gain attention (Luhmann 1990). Maps are ideal visual support for a controversial presentation: they combine a commonly accepted statistical relevance with the advantage of being eye-catchers. In this way, maps are not only relevant for academia and politics, but also for the constitution of the public sphere and public opinion, and it can be expected that the importance of maps will grow in the next media-dominated decades.

Since mappings of vulnerability and resilience are performative interpretations of reality, people act upon them (Thomas and Thomas 1928). When certain areas are rendered unsafe, this might lead to a self-fulfilling prophecy, because vulnerability can be increased by its mere attribution. A world map that describes areas or even continents as vulnerable by coloring them red, as for example with the *World Risk Report* (Alliance Development Works 2013), may have practical consequences that run contrary to the intentions (Bankoff 2003). Investors, for example, might use this map as guidance: although they may not know much about the concept of vulnerability and its implications, they understand the red color as a warning sign. But it is also important to recognize that mapping vulnerabilities might also have the opposite effect: once an area has been marked as "vulnerable," this might lead to an unjust distribution of resources whereby they are mainly directed towards vulnerable areas at the expense of others. Discourses of "underdevelopment" and the dependency of Southern countries on industrialized OECD (Organization for Economic Co-operation and Development) countries are also carried forward by mapping and visualizing vulnerability, leading to the multiple and largely destructive effects discussed within postcolonial studies (Bhabha 1994; Loomba et al. 2005). Furthermore, for numerous cultures, the (scientific) mapping of risks may be perceived as a provocation of celestial powers, with the direct consequence that such communities' feeling of security will be negatively impacted, with further significant consequences for their actions (Voss 2008). This holds true for matters large and small: valuation differences should be taken into consideration all over the world. Every failure to include such considerations, be it intended or not—for example, on a discourse level (see *dispositif*)—leads to distortions, the valuation of which can only be made on the social level, not based on exclusiveness demanding expert knowledge.

6 An Inductive Concept of Vulnerability: An Alternative Approach

While there are good reasons to critically reflect upon maps, we should also be aware that—as with statistics (Saetnan et al. 2010)—we can hardly give maps up altogether, since disaster preparedness planners, emergency managers, and scientists need data on how many people in different sorts of categories may need special intervention or assistance in a crisis, or additional information (King 2001). Rather, map-makers and map-users should be aware of the problems connected to maps in general (particularly vulnerability and resilience maps) in order to avoid pitfalls and misinterpretations of those maps. We also need to carefully reconsider the use of the maps we make, and be aware of the specific limitations of mapping.

What we need in matters of vulnerability and resilience mapping is not a positivistic construction and interpretation of maps, but their foundation on a contextual and differentiated exploration of concrete places (in this context also see the agency of the "participatory rural appraisal," Leurs

[2] Of course, there are prominent examples of artistic and subversive map designs, like Guy Debord's "Guide psychogéographique de Paris" (1955). But one can hardly imagine the use of such maps in a crisis situation.

1996). Places are subdomains of a physical environment, endowed with particular significance, values, and practices (for example, a particular neighborhood). The main focus here is on the interaction between an individual or group within a specific environment. In contrast, the production of a space occurs through the reciprocal interaction between people. A space is a more abstract framing of certain types of practice than, for example "nation" or "economic area" (Tuan 1979). Safety as physical integrity is constituted through concrete places. An inductive concept of vulnerability and resilience evolves from the specific to the general, focusing on given circumstances of vulnerability or resilience and feelings of security or insecurity. However, this focus should not only be related to geographically measurable units, but must also be widened to the social conditions that produce places and spatial entities. If we are well aware of such fundamental problems, then vulnerability and resilience maps should be seen in relation to historical trajectories and sociodemographic and sociopolitical parameters. As such, they can be accompanied by, and explained through, time series that provide information on the correlation of cultural and social norms and values, developments, income trends, and so on. This can make transparent complex historical (that is, long-term) cause and effect relationships, as well as the relativity of processes in the social history of the affected—at least selectively.

In a thorough interpretation of spatialization, a new and different approach is possible: a spatialized or regionalized idea of vulnerability focused on explaining danger from a concrete—and not abstract—perspective, where the bodily dimension is taken into account. This implies spotlighting "place" as an instantaneous context of intelligibility (Heesen 2008). In this sense, the spatialization of vulnerability can be conceived of as an indication of a context-related and inductive approach to the concept of vulnerability. This approach leads to an augmented picture of the production of security; a picture that includes the specific character of a place as an interplay between real factors, subjective perceptions, and intersubjective constructions.

The choice and weighting of factors forming the basis of mappings are hardly ever evident, but are subject to expert assessment that can differ greatly between nonprofessionals. Müller et al. (2011) illustrate this case with disagreements in the assessment of the most explanatory variables for vulnerability between professionals and nonprofessional residents. In most cases, local people in, and the inhabitants of, the area in question are not involved in the mapping process by public authorities. While it might be possible to include local actors in the decision-making process about what kind of data is being collected and how it will be processed, such participatory approaches to mapping are still rare when it comes to decision-making (Albrechtslund and Glud 2010). As Wood (2010, p. 111) put it, a "whole culture of counter-mapping has emerged" in the twenty-first century that challenges conventional concepts, but which at the same time remains "marginal and fragile" in opposition to state- and corporate-driven mapping. Rooted in development studies, approaches such as rapid rural appraisal or participatory rural appraisal (Chambers 1983, 1997) have given rise to alternative participatory techniques of describing, analyzing, and even mapping social realities—mainly in development programs in the Global South. Consequently, genuine participatory mapping or community-based mapping has developed under the influence of mental maps (Lynch 1960). In the case of marginalized indigenous peoples, not only in countries in the Global South, such as Indonesia (Peluso 1995), but also communities in developed countries such as the Inuit in the Territory of Nunavut (Wood 2010), participatory mapping serves as counter-mapping, displaying different claims and entitlements that are not present in the predominant discourse. The dissemination of information technology and GIS has led to a digitalization of participatory mapping and the development of participatory GIS (PGIS) or public-participation GIS (PPGIS). Such participatory approaches are used in the context of risk and vulnerability as well: Smith et al. (2000), for example, applied participatory risk mapping (PRM) to research and map risks faced by East African pastoralists; Reichel and Frömming (2014) used a PGIS approach to map the local DRR knowledge related to climate change in the Swiss Alps. As illustrated by counter-mapping approaches, it is not essentially necessary to compile one map involving all stakeholders, because sometimes the visualization of the different attributions of meaning within the same physical place by different stakeholders holds merit that is not to be underestimated—especially in relation to vulnerability issues (Voss 2008).

In response to this, the DRU developed an exploratory approach based on qualitative and ethnographic approaches such as participatory photography (Harper 2002; Gotschi et al. 2009), and participatory photo-mapping (PPM) (Liebermann and Coulson 2004; Dennis et al. 2009). Combined with GIS-mapping, this can ascertain and visualize the different attributions of risk and vulnerability by professional actors in emergency preparedness and response, as well as nonprofessionals from the general public. As part of the DRU project "Risk Attribution in Space" (Lorenz et al. 2014), participants (nonprofessionals of the general public and professionals in emergency preparedness and response, such as police, fire department, civil protection, and welfare workers, $N = 15$) were provided with digital cameras with integrated GPS units.

As a first step, participants were asked to take pictures of perceived hazards, risks, and vulnerability along fixed

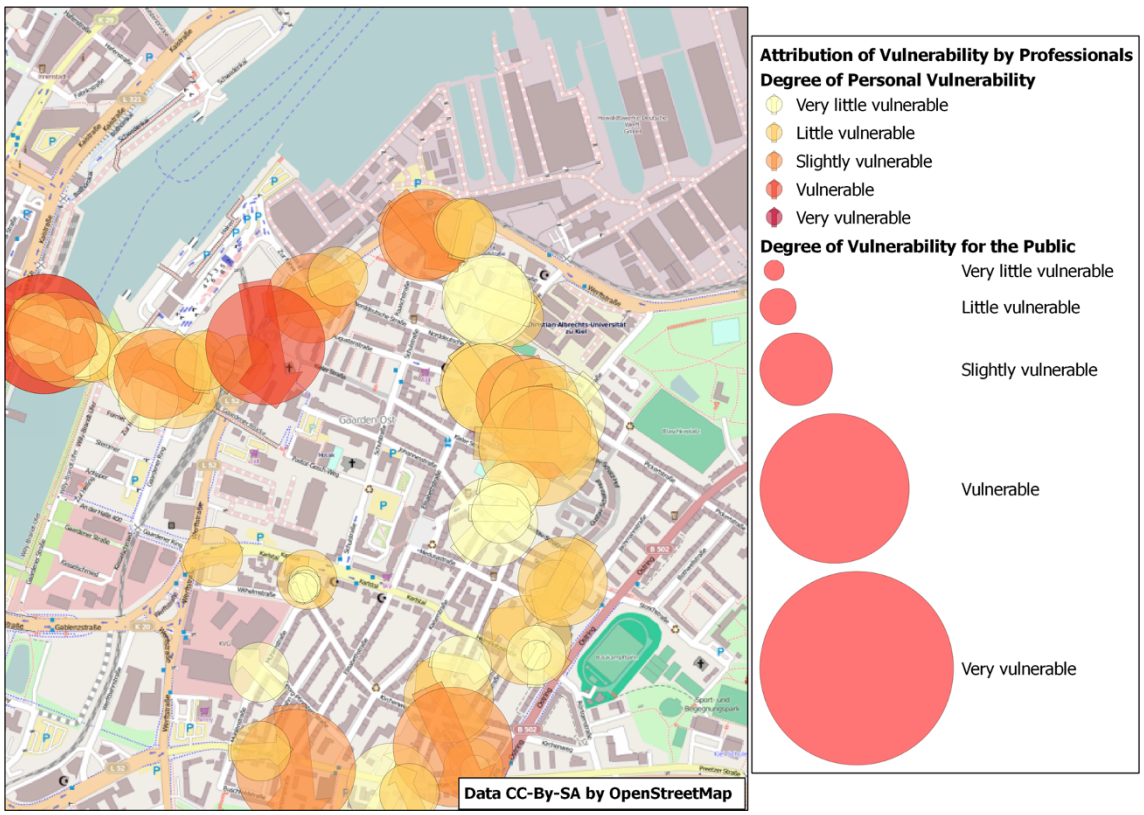

Fig. 1 Attribution of vulnerability by professionals in Kiel, Germany by means of photo mapping

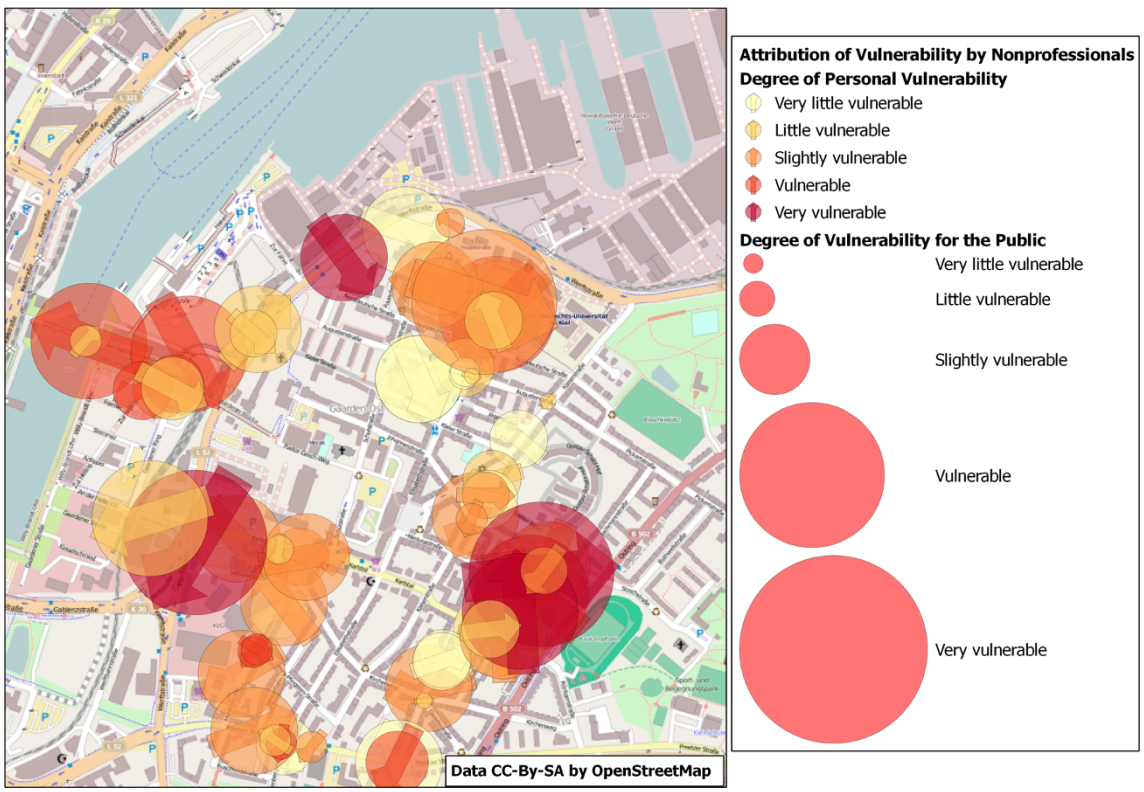

Fig. 2 Attribution of vulnerability by nonprofessionals in Kiel, Germany, by means of photo mapping

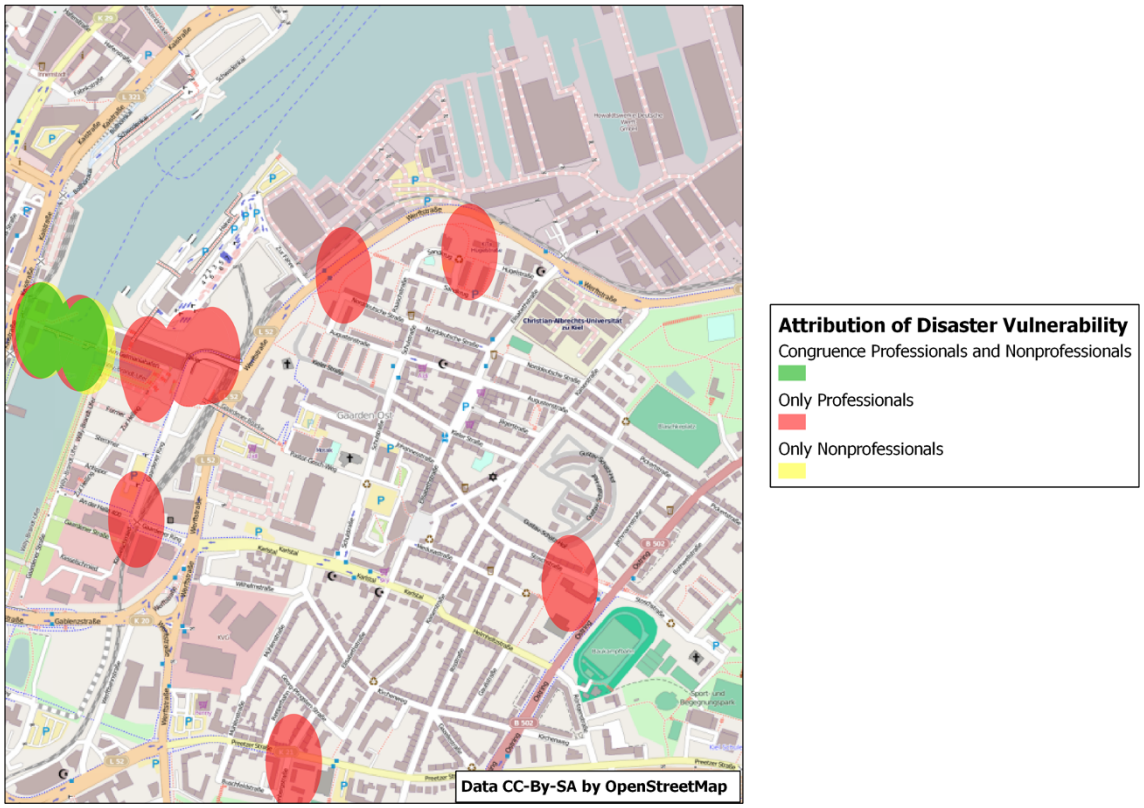

Fig. 3 Congruence and incongruence of professional and nonprofessional attribution of disaster vulnerability in Kiel, Germany

routes in known and unknown districts in the northern German cities of Kiel and Hamburg. In step two, additional data were gathered: the photographs taken by the participants became objects of detailed semistructured interviews, in which individual as well as professional attributions and meanings were attached to particular images and therefore locations. In step three, these images together with their attribution were mapped as part of a GIS allowing the individual attributions to be matched and contrasted, and additional spatial data to be included. In the fourth and final step the participants discussed the different attributions in stakeholder workshops. Contested knowledge among the participants became obvious and could be assessed in detail.

This methodological process favors a rather inductive understanding of the concept of vulnerability. In this sense, vulnerability is not limited to quantifiable, single key figures. Rather the concept opens itself to different cultural norms, different cosmologies, and divergent perceptions of vulnerability that arise from "practical" strategies (even though they originate from specific cultural standpoints), and creates a constant need to deal with biophysical and social environments, subjective perceptions, and intersubjective constructions. In contrast to other forms of participatory mapping (Smith et al. 2000), the participants need neither conceptual nor spatial knowledge about the districts, perceived risks or vulnerabilities. They can focus on their situational perception of the biophysical and social environments in terms of insecurity. Such an approach is rooted in the everyday experience of the living environment. With the given combination of qualitative and spatial methods the resulting maps do not provide an objectivistic display of vulnerability but rather show the different attributions of stakeholders and the relevance of different forms of knowledge in these attributions in capturing the complexity and manifoldness of vulnerability.

Therefore, the differences in attribution between nonprofessionals and professionals can be assessed and compared, both in qualitative detail and with spatial accuracy. The maps provide a subjective account of personal and communal vulnerability as perceived by professionals (Fig. 1) and nonprofessionals (Fig. 2). The color indicates the personal vulnerability (from yellow to red); the diameter indicates the vulnerability of the local people. The incongruence of different attributions within the same physical place by different stakeholders indicates a gap in the perception of disaster vulnerability (Fig. 3). But without arguing for more adequate perceptions among specific stakeholders, an argument that is often implicit in comparisons of professional and nonprofessional judgments, such an approach acknowledges the very different conceptions of vulnerability. The combination of GIS and

qualitative interviews allows analyzing the underlying drivers for the different attribution in detail with respect to different perceptions, understandings, and constructions of vulnerability. This is not only instructive for theoretical purposes but also most relevant for the practice of disaster preparedness. The detailed trial reveals, for example, that the attribution made by professionals and not by the general public is not due to ignorance but rather explained by specific expert knowledge that is simply not available to the general public.

The demonstration of the differences and their explanation are not just scientifically significant, but also a means of communication. The discussion of the scientific results in stakeholder workshops (step four of the methodology) with the participating professionals in emergency preparedness and response and nonprofessionals of the general public has practical consequences, since the comparative mapping raises awareness of different perceived realities among professionals and nonprofessionals that might conflict in emergency situations. Even though the focus within this research project has been on vulnerability while individual perspectives on resilience played a subordinate role, it would be possible to use the developed method to focus on resilience in forthcoming projects.

7 Conclusion and Outlook

Vulnerability and resilience are scientific concepts that try to capture complex social and cultural phenomena and their interplay that lead to disaster or to the development of the capacity to cope with extreme adverse conditions. Logically, these cultural and social phenomena cannot be objectified or even quantified to any full extent. The production of maps as spatializations and objectifications of temporal and spatial scales surmounting social processes reduce complexity on the reflexive-conceptual level. These limitations are due to the selective characteristic of maps. A map itself often gives no information about the origins of the data, the intentions and selections of the map-maker, and the transparency and comprehensibility of the mapping process thus remain unclear. We suggest that the stages of indicator selection, data sourcing, data processing, and other decisions should be made consciously and transparently, or should be scrutinized if transparency is not apparent. But the problem goes deeper: maps of vulnerability and resilience often seem like ends in themselves, but as maps become *dispositifs*, they shape the social and political construction of reality, including the disaster culture in terms of disaster preparedness and management. Maps should rather be understood and treated as a means of communication; therefore it is necessary to contest the process of objectification in cartography, or to reflect the objectification itself as cultural code. We do not believe that such alternative approaches will replace the predominant positivistic procedures of mapping in the foreseeable future, since the reduction of complexity is frequently desired to support decision-making. But alternative approaches that recapture the complexity of vulnerability illuminate the subtle reductionism of the discourse, and contribute to a gradual change.

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